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Applicant and
Inventor: SCHULZ-HARDER, Juergen [DE/DE]; Hugo Dietz Strasse 32, 91207 Lauf (GE)

Attorneys: GRAF, Helmut at al; Grellingerstrasse 7, 93055 Regensburg (DE)

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Title: Process for producing a metal-ceramic substrate, preferably a copper-ceramic substrate

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Refer to the Explanations ("Guidance Notes on Codes and Abbreviations) at the beginning of each regular edition of the PCT Gazette for an explanation of the two-letter codes and other abbreviations.

The invention relates to a process as claimed in the preamble of claim 1.

The production of metal-ceramic substrates and especially copper-ceramic substrates for electrical wiring and circuits is known in the most varied versions. Producing the metal coating which is required for producing conductive tracks, terminals, etc. on a ceramic, for example on an aluminum oxide ceramic, using so-called "DCB process" (direct copper bond technology) is also especially known here, using metal or copper foils or metal or copper sheets which form the metal coating and which on their surface sides have a layer or a coating (melted-on layer) of a chemical compound of a metal and a reactive gas, preferably oxygen. In this process which is described for example in US-PS 37 44 120 or DE-PS 23 19 854 this layer or this coating (melted-on layer) forms a eutectic with a melting point below the melting point of the metal (for example, copper) so that by placing the foil on the ceramic and by heating all the layers they can be joined to one another by melting on the metal or copper essentially only in the area of the melted-on layer or oxide layer. This DCB process then has the following process steps:

- oxidization of a copper foil such that a uniform copper oxide layer results;
- placing the copper foil on the ceramic layer;
- heating the composite to a process temperature between roughly 1025 to 1083°C, for example to roughly 1071°C;
- cooling to room temperature.

After applying the metal foils, at least on the surface side of the ceramic layer, structuring of the metal foil there, for example copper foil (also DCB copper), takes place to form conductive tracks, contact surfaces, etc.

Furthermore, the so-called active brazing process (DE 22 13 115; EP-A-153 618) is

known, especially also for producing metal-ceramic substrates. In this process, at a temperature between roughly 800-1000°C a bond is formed between a metal foil, for example, copper foil, and a ceramic substrate, for example aluminum nitride ceramic, using a brazing solder which in addition to the main components such as copper, silver and/or gold, also contains an active metal. This active metal which is for example one element of the group Hf, Ti, Zr, Nb, Cr produces a bond between the brazing solder and the ceramic by a chemical reaction, while the bond between the brazing solder and the metal is a metallic brazing bond.

The production of metal-ceramic substrates takes place preferably in a multiple printed panel such that on a ceramic substrate with a large area several individual substrates are formed spaced apart from one another and then each have conductive tracks, contact surfaces, etc. On scored lines which are made in the ceramic substrate preferably by means of a laser, this multiple printed panel can then be divided later into individual substrates by breaking, for example, after assembly.

The object of the invention is to devise a process with which the production of metal-ceramic substrates with improved properties is easily possible. A process as claimed in claim 1 is devised to achieve this object.

A high temperature bonding process as claimed in the invention is a process with which at a temperature greater than 650°C a bond between the respective metal foil and the ceramic substrate or the ceramic layer is produced. A high temperature bonding process is therefore the above described direct bonding process, and when using copper, the above described DCB process. A high temperature bonding process for the purposes of the invention is however also the above described active brazing process.

It has been found that surprisingly in metal coatings which are applied with a high temperature bonding process to the ceramic substrate especially reliable adhesion of the brazing resist is achieved. According to a finding which underlies the invention this can apparently be attributed to grain enlargement of the material structure of the metal coatings which (grain enlargement) occurs in the high temperature bonding process.

In the invention the application of at least one coating to the brazing resist (brazing resist coating) takes place for example immediately after structuring of the pertinent metal coating, optionally after intermediate cleaning. This prevents possible fouling of the metal surfaces which adversely affects the adherence of the brazing resist before application of at least one brazing resist coating. It has also been surprisingly found that for metal surfaces which are formed by the DCB copper, especially reliable adhesion of the brazing resist is achieved and migration of the brazing resist down during brazing is effectively prevented although the copper metal coating which has been applied by means of the DCB process has an increased proportion of oxygen.

In the process as claimed in the invention it is furthermore also possible for the brazing resist to be applied to the metal coating even before the structuring of the pertinent metal coating. If the conventional etching and masking technique is used for structuring of the metal coating, in which an etching resist is applied for example in the form of a photo resist or silk screen resist, for the brazing resist a resist is used which compared to conventional agents which are used for etching and/or removing the mask from the etching resist is especially resistant to the alkali solutions which are conventionally used here. An epoxy-resin based resist is especially suited here as the brazing resist.

It was assumed above that in the process as claimed in the invention the application of

metal coatings to the ceramic substrate takes place using the direct bonding technique. Of course in the invention also other high temperature bonding processes or techniques can be used, for example the active brazing process.

If the metal-ceramic substrate is produced in a multiple printed panel, as is preferably the case, the brazing resist is applied before the scored lines are made in the ceramic substrate, therefore before oxidation and/or fouling of the metal surfaces which adversely affects adhesion of the brazing resist, for example by laser plasma when the scored lines are produced, could occur.

Developments of the invention are the subject matter of the dependent claims. The invention is detailed below using the figures on various embodiments.

Figure 1 shows in a simplified representation and in a section a copper-ceramic substrate which has been produced using the process as claimed in the invention;

Figure 2 shows in positions a-d the different process steps in one possible embodiment of the process as claimed in the invention for producing the substrate of Figure 1;

Figure 3 shows in an enlargement a partial section through a substrate which has been produced using the process as claimed in the invention in the area of a brazing resist coating after removal of the metal of the bordering metal surface;

Figure 4 shows a representation similar to Figure 3, but with subsequent metal coating;

Figure 5 shows a representation similar to Figure 3, but with a structured brazing resist coating;

Figure 6 shows an overhead view of the structured brazing resist coating;

Figure 7 shows a representation like Figure 2 in another version of the process as claimed

in the invention.

Figures 1 and 2 show a ceramic-copper substrate consisting of a ceramic layer 2 and metal coatings 3 and 4 which are provided on the two surface sides of the ceramic layer 3 and which are structured in the required manner to form conductive tracks, contact surfaces, etc., and consist of copper. In certain areas of the metal coatings 3 and 4 brazing enamel coatings 5 are applied which are made for example strip-shaped, but can also have a different shape and which in the assembly of the substrate 1 with components border that area of the metal coating 3 and 4 which is to be wetted by the brazing solder used. With the coatings 5 which extend for example along the edges of the contact surfaces and the conductive tracks produced by the structuring, the brazing compound used in assembly of the substrate 1 is prevented from flowing into the intermediate spaces 6 which are formed between the conductive paths, contacts, etc., and which electrically separate them and the resulting short circuits between the conductive tracks are prevented.

The substrate 1 is produced with the process steps shown in Figure 2, i.e. first copper foils 3' and 4' are applied to the ceramic layer 2 using the DCB technique so that these copper foils 3' and 4' are bonded on their entire surface to one surface side of the ceramic layer 2 at a time.

Subsequently, according to steps b) and c) of Figure 2 the structuring of the copper foils 3' and 4' takes place for formation of the structured metal coatings 3 and 4, with the conventional etching and masking technique by application of a mask 7 of a photo resist or etching resist and subsequently etching away the areas of the copper foils 3' and 4' which are not covered by the mask 7 (position b) so that finally after removal of the mask 7 the intermediate product which is

shown in position c is obtained, consisting of the ceramic layer 2 and the structured metal coatings 3 and 4. In a subsequent process step the brazing resist coatings 5 are produced for example by a screen printing process so that finally the substrate 1 which is shown again in position d is obtained.

The brazing resist coatings 5 are done with a thickness such that these coatings 5 have a thickness between 0.5 to 100 microns after curing of the brazing resist. For example an epoxide-based resist is used as the brazing resist. The brazing resist is cured by heating.

It has been found that when the brazing resist is applied immediately after the DCB process or immediately after completion of structuring of the copper foils 3' or 4' by the etching and masking technique optimum adhesion of the brazing resist to the copper foils is achieved and especially the brazing resist coating is effectively prevented from migrating down through the brazing solder during later assembly of the substrate 1 without the fundamental necessity of cleaning the metal surfaces before application of the brazing resist.

In the described process however it is also possible to additionally clean the surfaces of the metal coatings 3 and 4 after structuring. For this additional cleaning or intermediate cleaning the most varied cleaning processes are conceivable, for example also by removing a surface area of the coatings 3 and 4. Especially for this purpose can a chemical process be used by employing an acid hydrogen peroxide solution or an acid sodium persulfate solution. Furthermore intermediate cleaning of the surfaces of the metal coatings 3 and 4 by plasma etching and/or electrochemical or electrolytic etching (galvanic removal of copper) is possible. Moreover, purely mechanical cleaning processes, for example by brushing, grinding or the like, can be used.

Figure 3 shows in an enlargement a partial section through a copper-ceramic substrate 1a

in which the metal coatings 3 and 4 at least in surface areas which border the brazing resist coating 5 are removed by a chemical etching process as far as the surface 8. The brazing resist coating 5 is used here as masking during etching. The etchant can also be basically agents which dissolve copper, for example acid hydrogen peroxide, acid sodium persulfate, copper chloride, iron chloride, etc. Removal takes place for example with a thickness from 0.1 to 20 microns so that the brazing resist coating 5 is then located on a projection 9 which projects over the surface 8 which has been produced by removal. This execution can greatly improve the action of the brazing resist coating 5.

Furthermore, according to Figure 5 there is the possibility of applying to the abraded surface areas 8 an additional surface metal coating 10 which then lies with its surface side lower or in one plane with the original surface of the metal coating 3 and 4 which has not be removed, under the brazing resist coating 5. The metal coating 10 for example forms a corrosion-resistant metal surface or in general a surface which greatly improves further processing of this substrate 1b. The metal for the additional metal coating 10 is for example nickel or phosphorus nickel. The application of the additional metal coating 10 takes place for example without current by chemical precipitation.

But basically it is also possible to form the metal coating 10 in several layers, for example consisting of a lower first layer which directly borders the surface 8, for example of nickel, and an external layer of gold or tin.

Figures 5 and 6 show as another possible embodiment a substrate 1c in which at least one brazing resist coating 5 in a component area 5' is worked with a suitable technique such that on the surface of the substrate in this area 5' an optically visible structure in the form of a bar code or

data matrix code results. This code which is readable for example with a camera system then contains various data which relate to the respective substrate, for example the article number, but also other data which are necessary for example for monitoring and/or control of production, such as for example the production date, batch number, etc.

The structuring of the area 5' takes place for example by means of a laser by burning the structure or the code into the brazing resist coating 5 or by partially burning away the coating 5 for the structure.

Preferably the substrates 1 - 1c are produced in a multiple printed panel, i.e. a correspondingly large ceramic substrate is first provided on the two surface sides in the above described manner with copper foils 3' and 4' and they are then structured such that the structured metal coatings 3 and 4 form not only conductive tracks, contact surfaces, etc. of a single copper-ceramic substrate, but a plurality of these individual substrates on a common ceramic plate. After structuring and preferably also after application of the brazing resist coatings 5 then so-called "laser scribing" of the ceramic substrate takes place to form scored lines on which the multiple substrate can be broken into individual substrates for example after assembly with components. Scribing takes place for example with a laser (for example, a CO_2 or YAG laser). Then the laser which has been used for scribing can be used for structuring the area 5' or for applying the code.

Figure 7 shows in a representation similar to Figure 2 the individual process steps for producing the ceramic-copper substrate 1 in a production process which has been modified compared to Figure 2. According to the position a of Figure 7 in turn one metal foil 3' or 4' at a time is applied to the ceramic layer 2 on both sides, for example using the DCB technique. Immediately after this process step and before structuring of the copper foils 3'and 4' the brazing

resist coatings 5 (position b of Figure 7) take place. In the subsequent process steps c and d then structuring of the copper foils 3' and 4' takes place for formation of the structured metal coatings 3 and 4 with the conventional etching and masking technique by application of the mask 7 from the etching resist, for example by structured application of the etching resist by a printing technique (for example, by screen printing) or by a photo technique using a photo resist and by subsequently etching away the areas of the copper foils 3' and 4' which were not covered by the mask 7 (position d) so that finally after removing or "stripping" the mask 7 a copper-ceramic substrate 1 is obtained with the brazing resist coatings 5 on the structured metal coatings 3 and 4. For the brazing resist coatings a resist is used which compared to the conventional materials used in the masking and etching technique is also resistant to the materials used for removing the mask 7 (alkali solutions). The brazing resist in this version of the process as claimed in the invention can be in turn epoxy resin-based resists.

It has been found that in this process especially reliable adhesion of the etching resist to the metal foils 3' and 4' and to the later structured metal coatings 3 and 4 is also attained; among others in turn this can be attributed to the grain enlargement of the copper in the DCB process.

The invention was described above on various versions. It goes without saying that numerous other changes and modifications are possible without in this way departing from the inventive idea underlying the invention.

It was assumed above that the bonding of the metal foils or copper foils to the ceramic layer 2 takes place using the DCB process. Basically also another high temperature bonding process can be used, for example the active brazing process, especially when the ceramic layer 2 consists for example of an aluminum nitride ceramic.

Reference number list

1, 1a, 1b, 1c	copper-ceramic substrate
2	ceramic layer
3, 4	structured metal coating
3', 4'	copper foil
5	brazing resist coating
5'	structured area
6	intermediate space
7	mask
8	metal or copper surface produced by removal
9	projection
10	additional surface metal coating